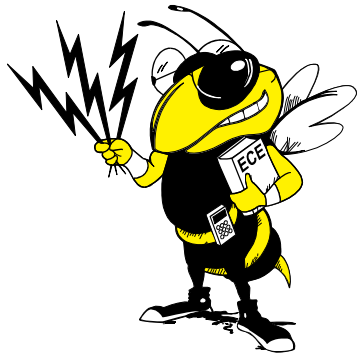


TPA SEE Testing Procedures at NRL: from System Calibration to Experiment

Adrian Idefonso

iadrian@gatech.edu

School of Electrical and Computer Engineering
Georgia Tech, Atlanta GA 30332-0250 USA



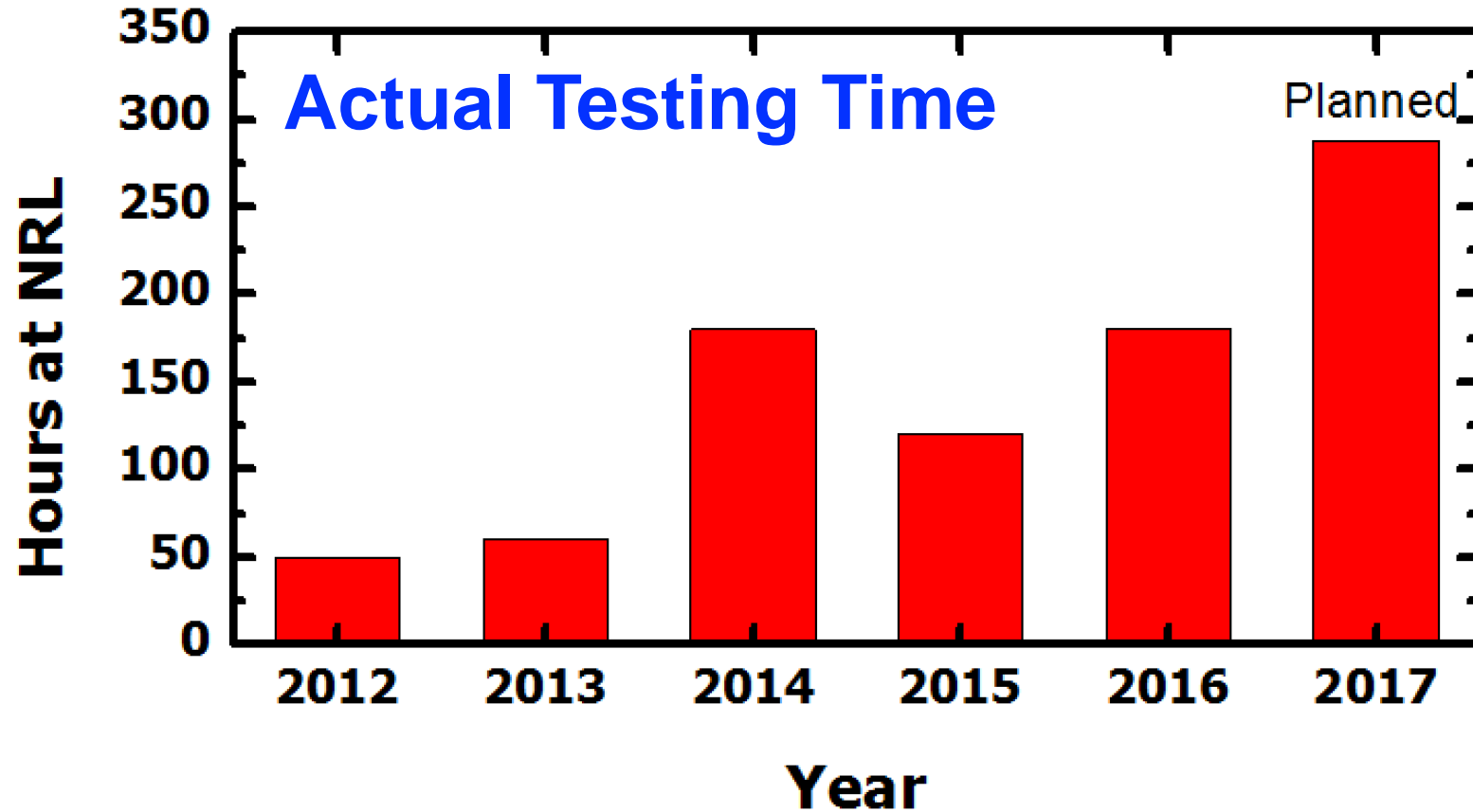
Work presented was partly supported by DTRA under contracts HDTRA1-16-1-0018 and HDTRA-1-13-C-0058, and by the NSF Graduate Research Fellowship under Grant No. DGE-1148903.

- **Research Overview**
- **NRL TPA Setup**
- **GT Experimental Practices**
- **Summary**

- **Device Physics, Profile Design, Modeling, Scaling Limits**
- **RF, Communications, Radar and Radiometry Systems**
- **Wide-Temperature Range Electronics** (50 mK to 300°C!)
- **Si/SiGe Photonics** (HBTs and all photonics but the laser on die)
- **Radiation Effects in Devices and Circuits** (space-systems)
 - **People:** 11 PhD, 7 MS, 2 post docs, 2 UG, 1 visitor
 - **Publications:** 18 journal papers, 19 conference papers (2016)
 - **Funding:** DTRA, NASA, DoD, DoE, GTRI, many industry partners
 - **Tapeouts:** 12 in 2016 (214 mm²!); all leading SiGe foundries

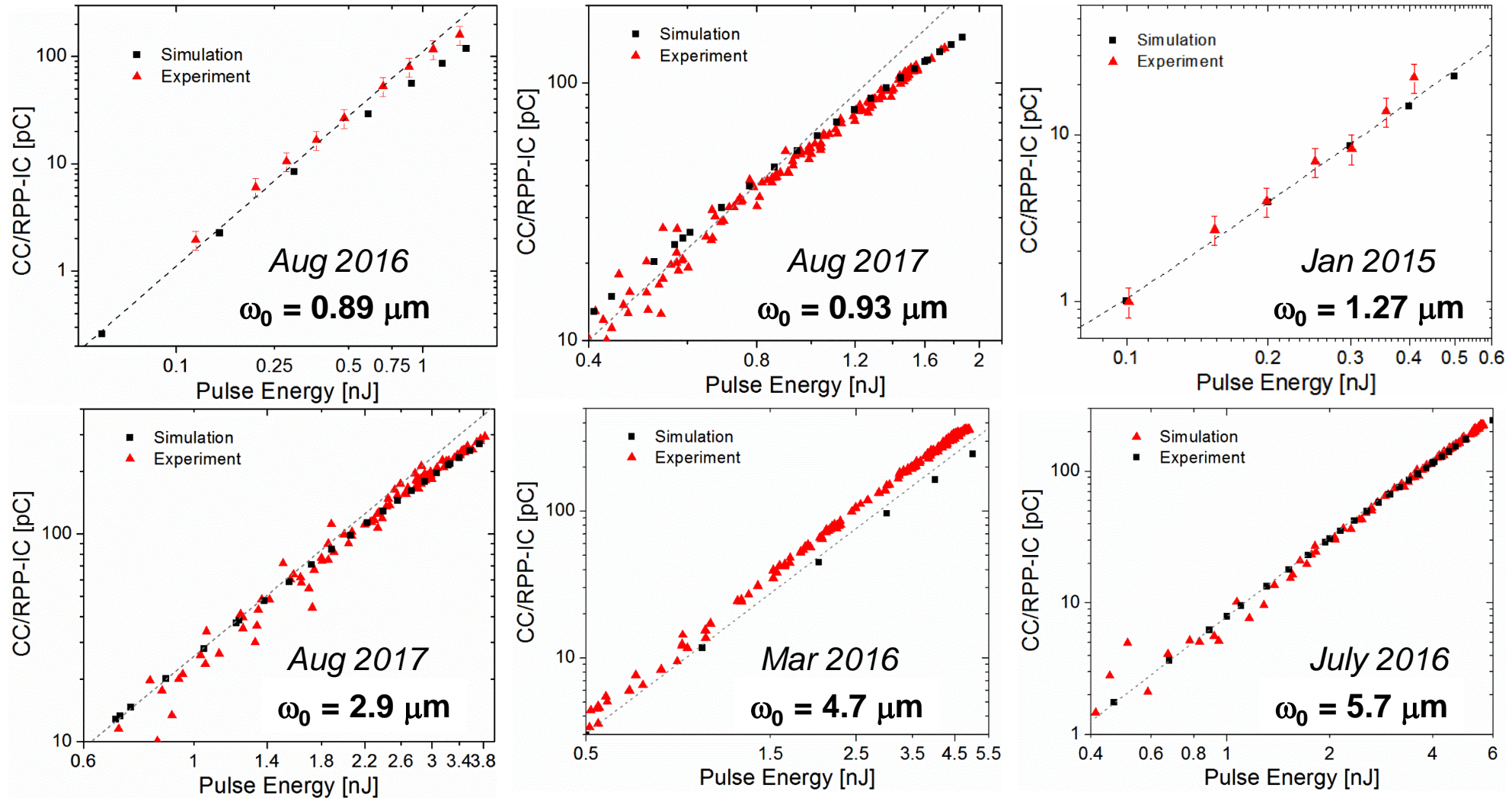
Over 65 Papers Generated in 5 years!
> 75% from Collaborations with NRL!

History of Work with NRL

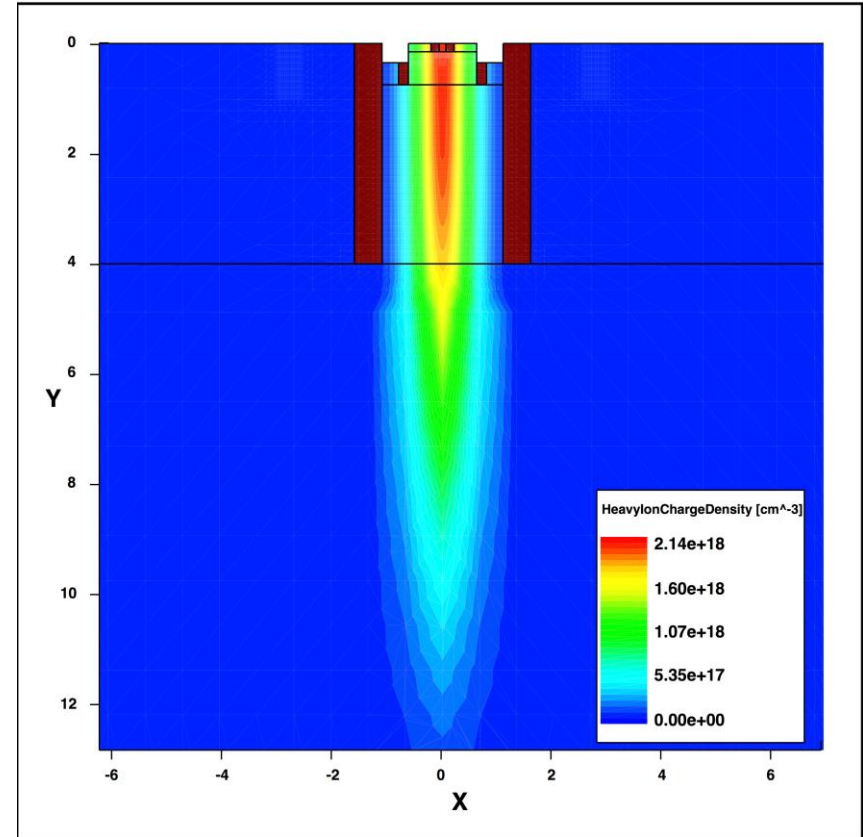
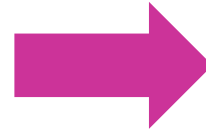
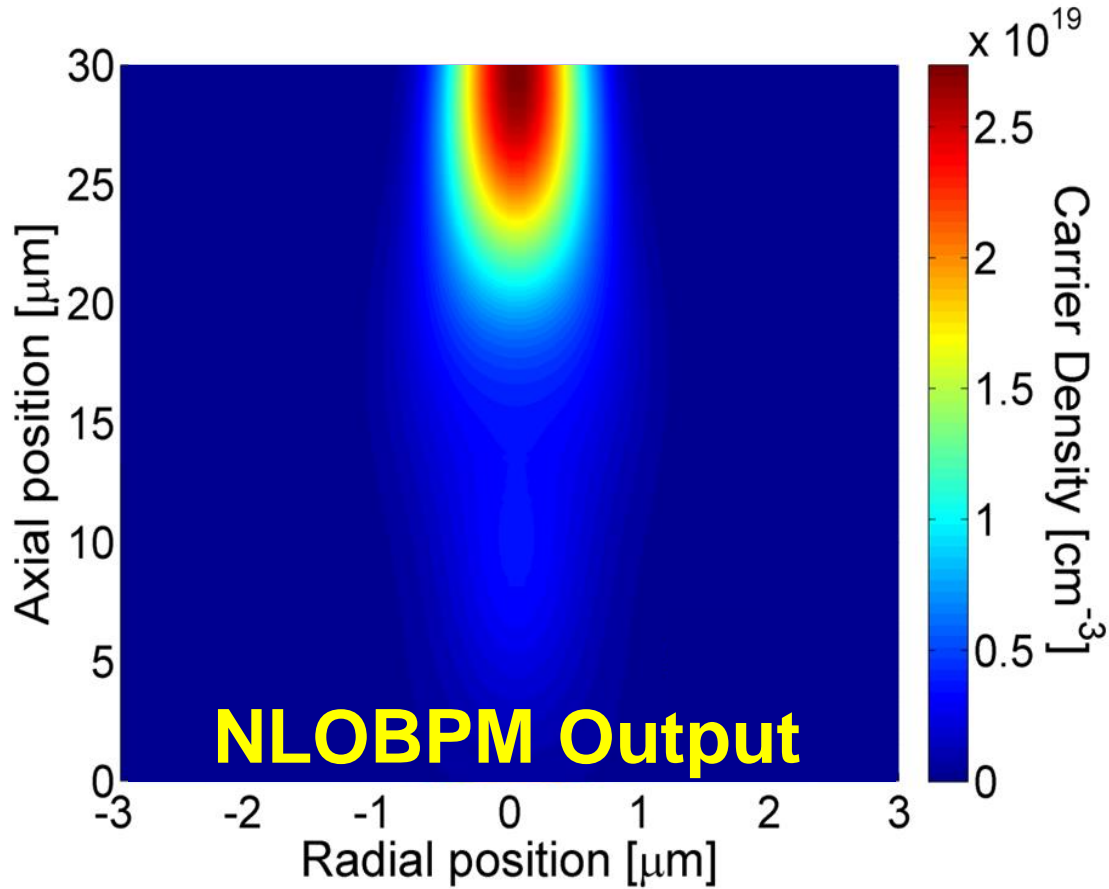


**Additional Experiments Performed at GANIL,
GSI, and Argonne National Lab!**

Measurements Taken Over 2.5 Years Using Multiple Laser Geometries

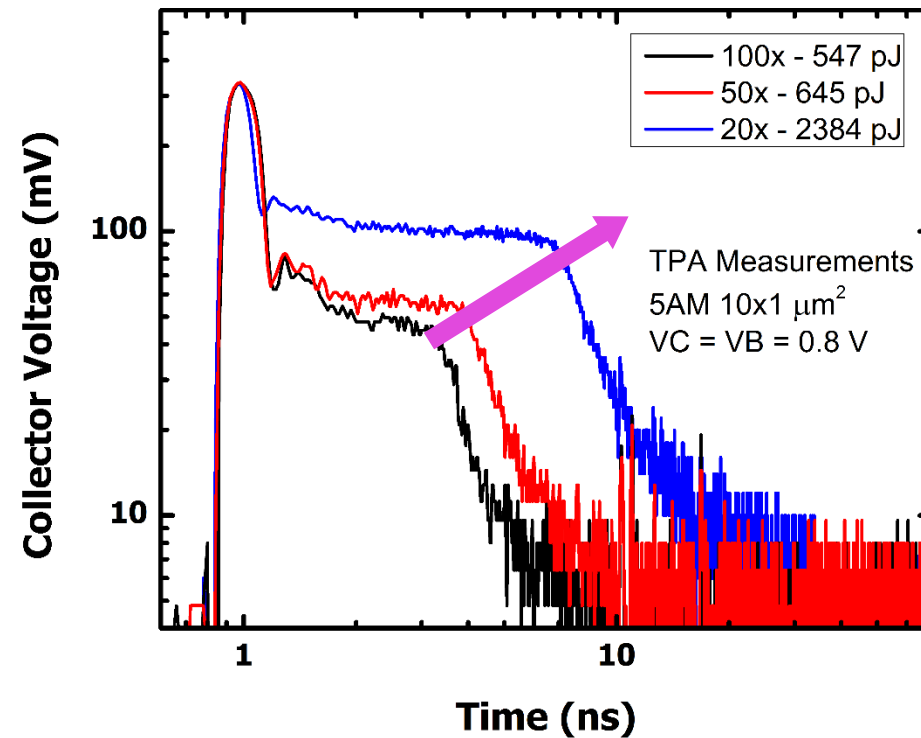
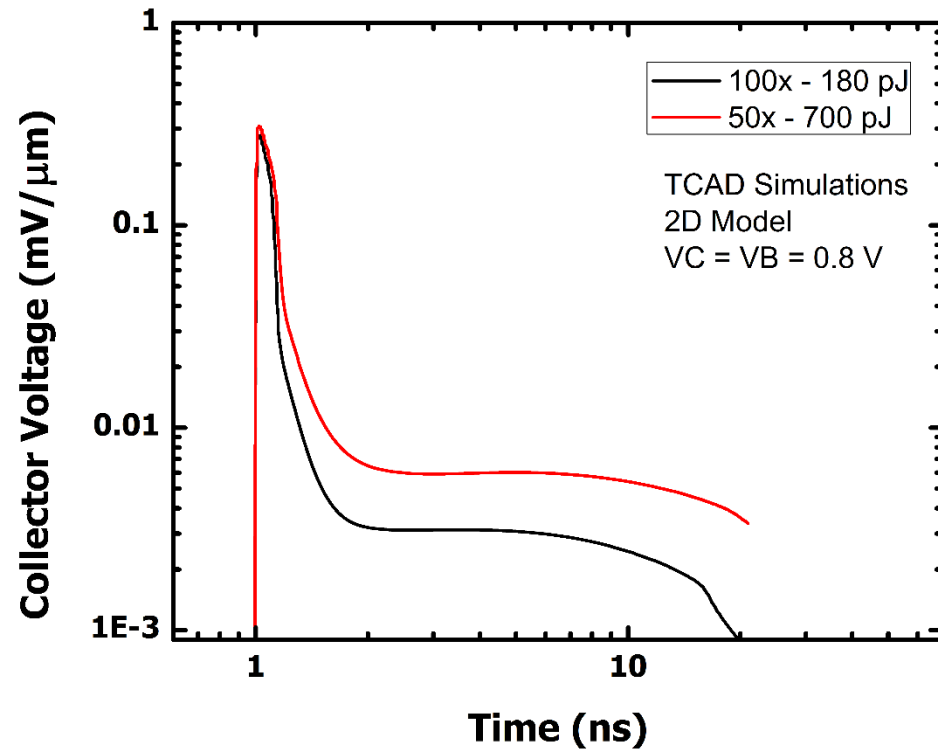


Simulated Beam Profiles Can Enable Predictive TCAD



PE = 190 pJ (100x Objective)
Input Beam = 2mm

- SET Measurements of SiGe HBTs
- Increased Tail Predicted by Simulations!
 - differences in shape result from TCAD model calibration



- **We Have a Great Laser System!**
 - result several years of optimization and calibration
 - beam profile simulations can enable predictive TCAD simulations

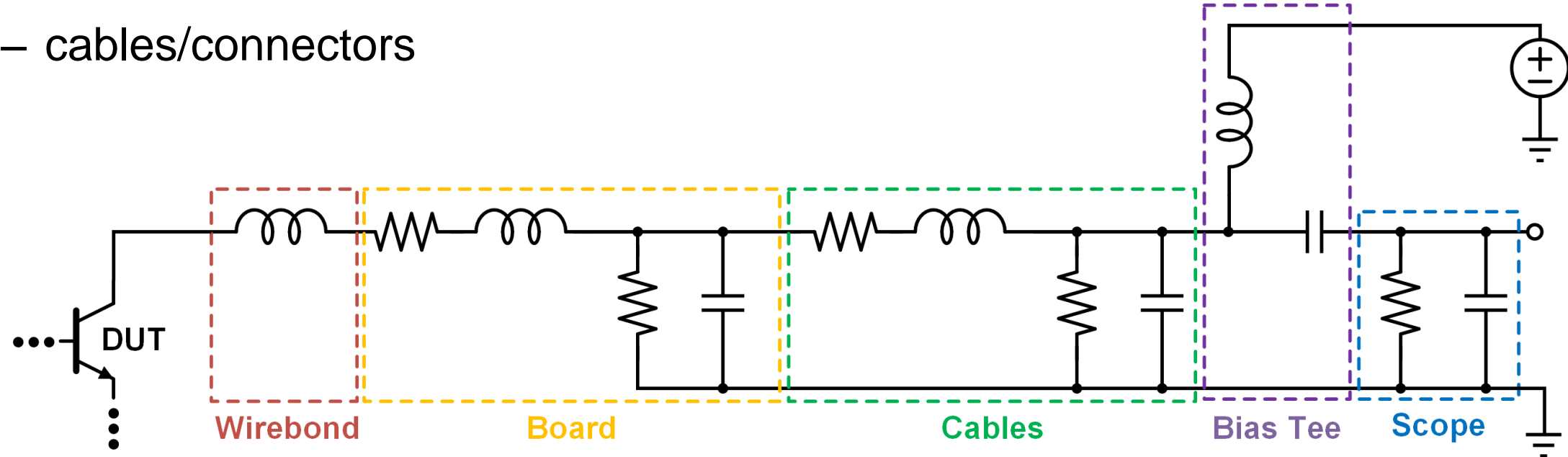
- **How Do We Get the Best Possible Results?**
 - reliable laser calibration
 - consistent sample preparation and experimental setup
 - data validation: "plot as you go!"

- **Pulse Width**
 - autocorrelation measurements (weekly)
- **Energy Calibration**
 - reference InGaAs diode and power meter (daily)
- **Spot Size Measurement**
 - correlation between InGaAs and Si diodes [1] (daily)
- **Golden Device**
 - testing a known device (sanity check)

[1] A. Khachatryan, et. al., "A Dosimetry Methodology for Two-Photon Absorption Induced Single-Event Effects Measurements," in *IEEE Transactions on Nuclear Science*, vol. 61, no. 6, pp. 3416-3423, Dec. 2014.

Consistent Sample Preparation

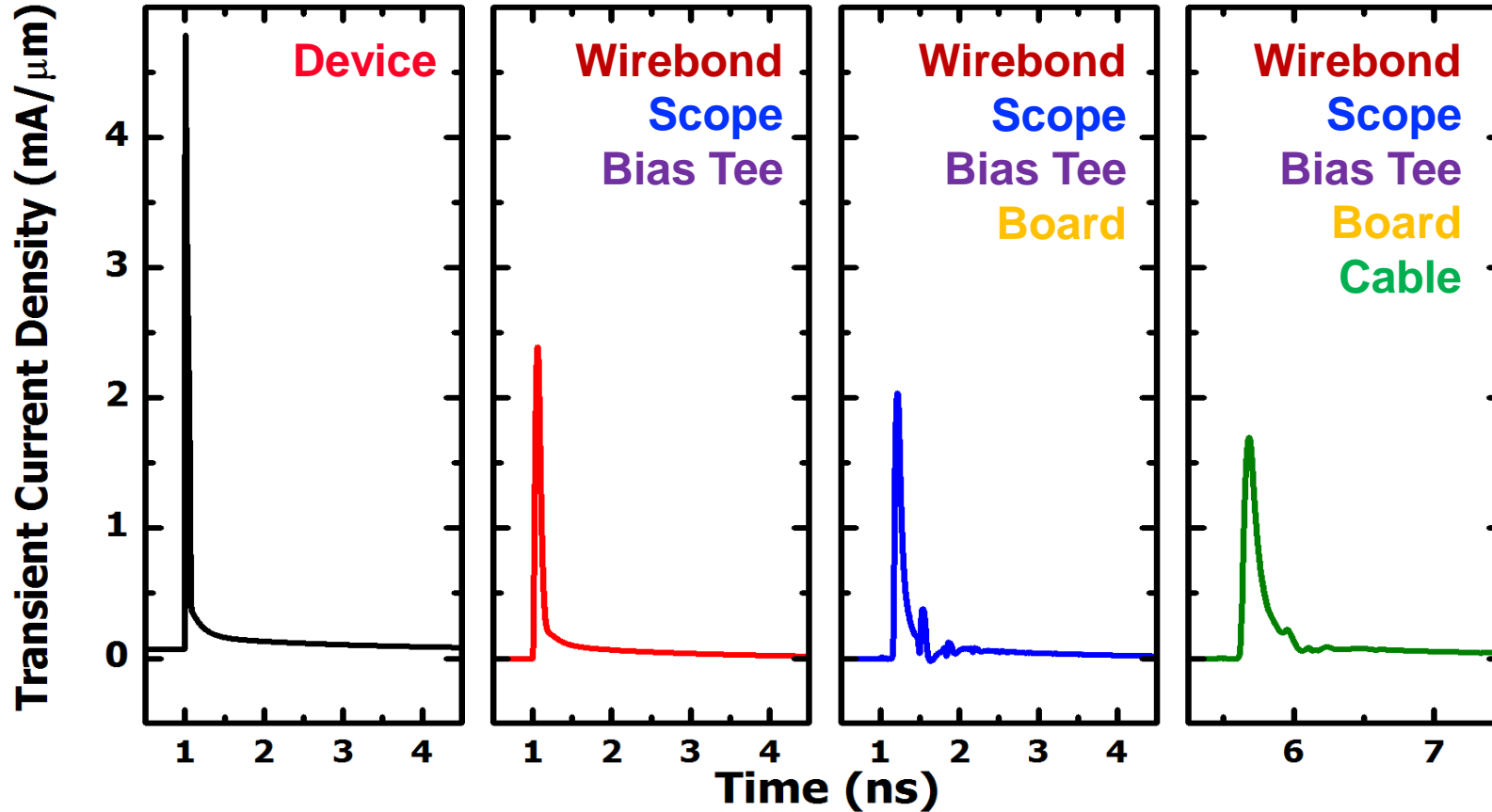
- SETs Have High-Frequency Components
- Transients Can Be Affected By:
 - wirebonds + boards
 - cables/connectors



Could Lead to Issues When Comparing Data from Different Experiments!

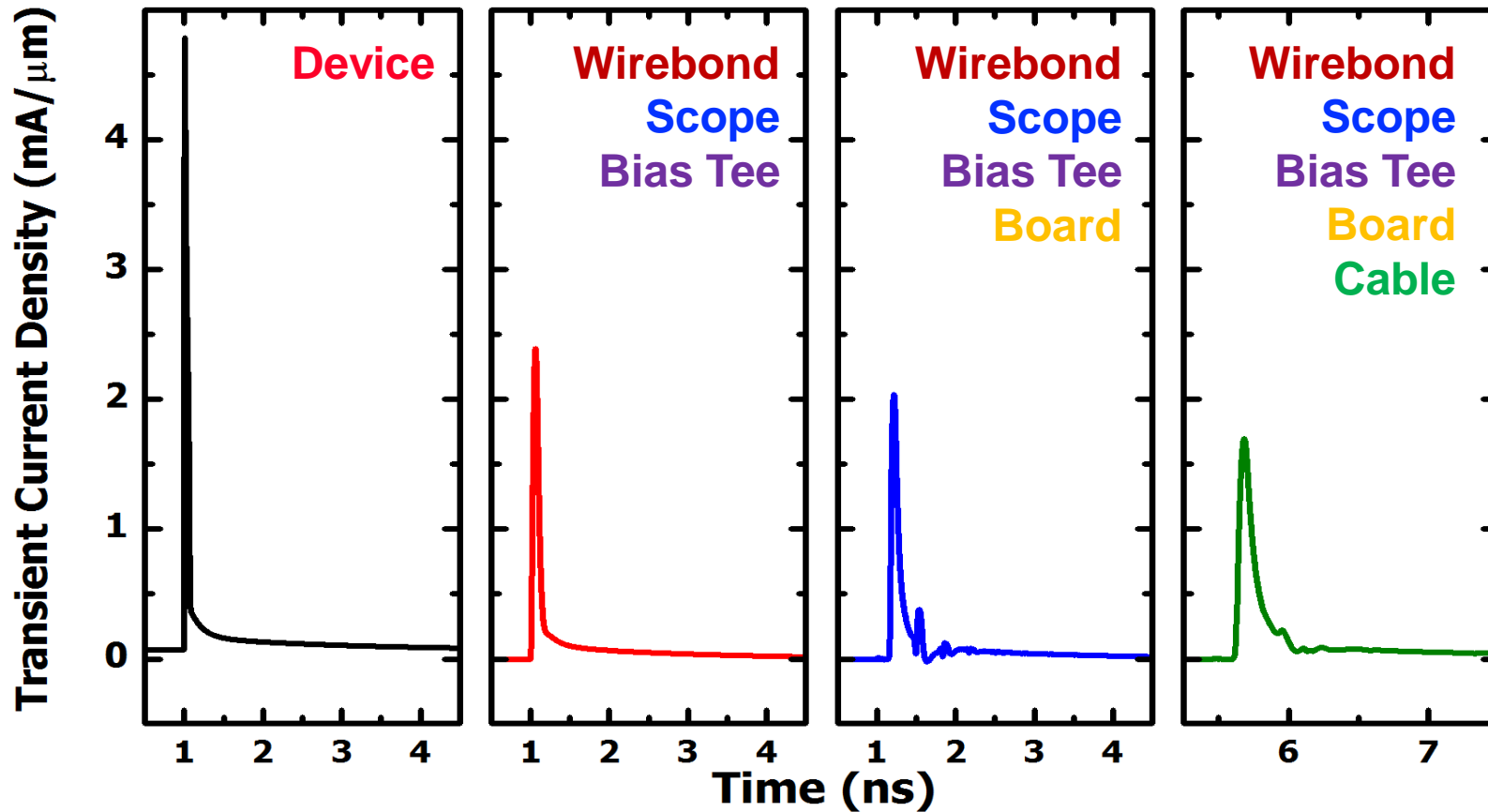
Parasitics From Experimental Setup

TCAD Simulations Show Effects of Test Setup on SETs

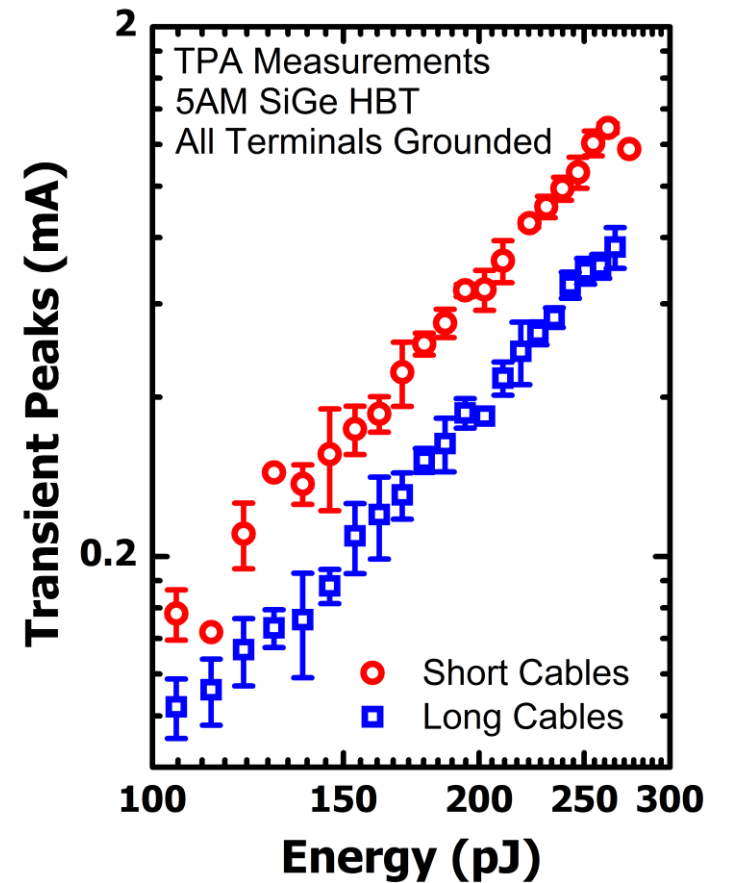


Parasitics From Experimental Setup

TCAD Simulations Show Effects of Test Setup on SETs

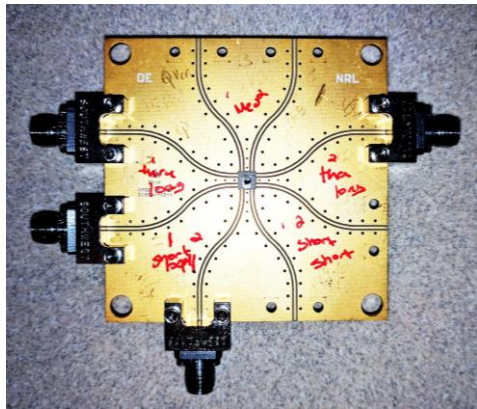
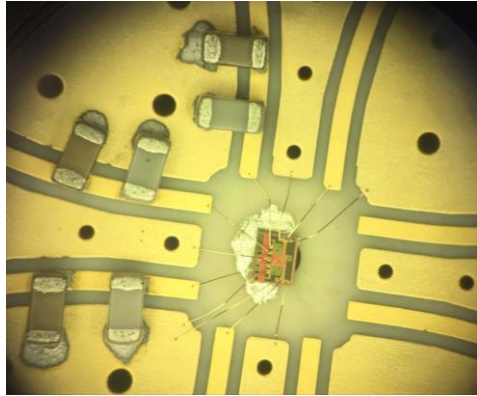


Same Trend Observed in Measurements

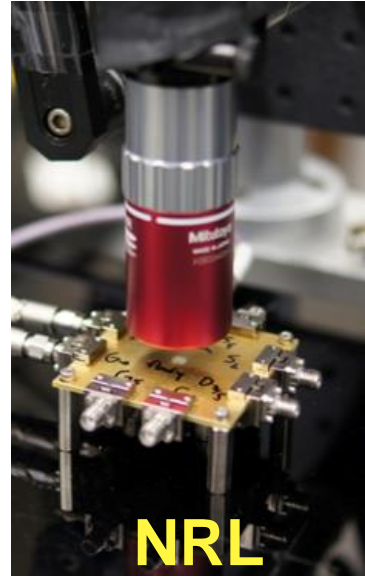


Consistent Experimental Setup

Samples Bonded to Same Boards



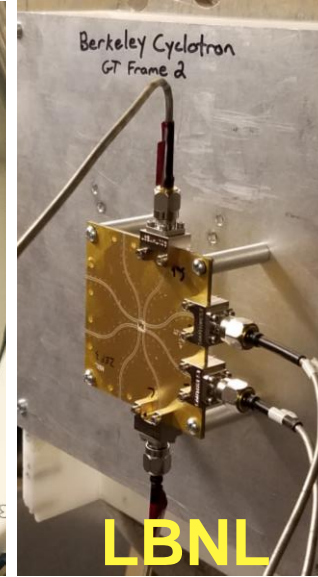
Same Boards Used for Multiple Experiments



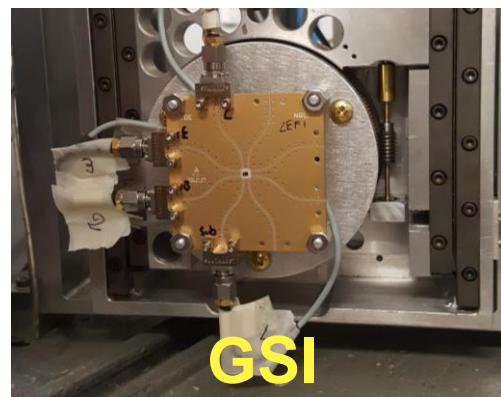
NRL



GANIL



LBL

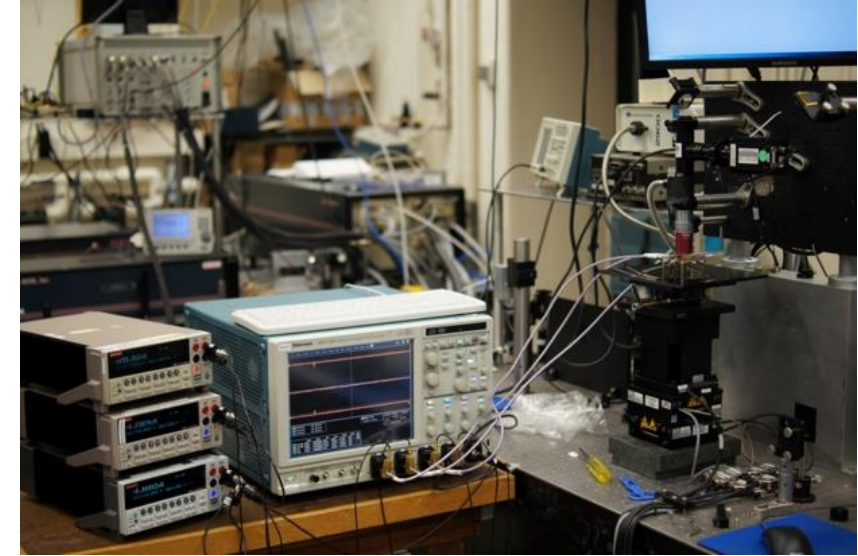


GSI



Argonne

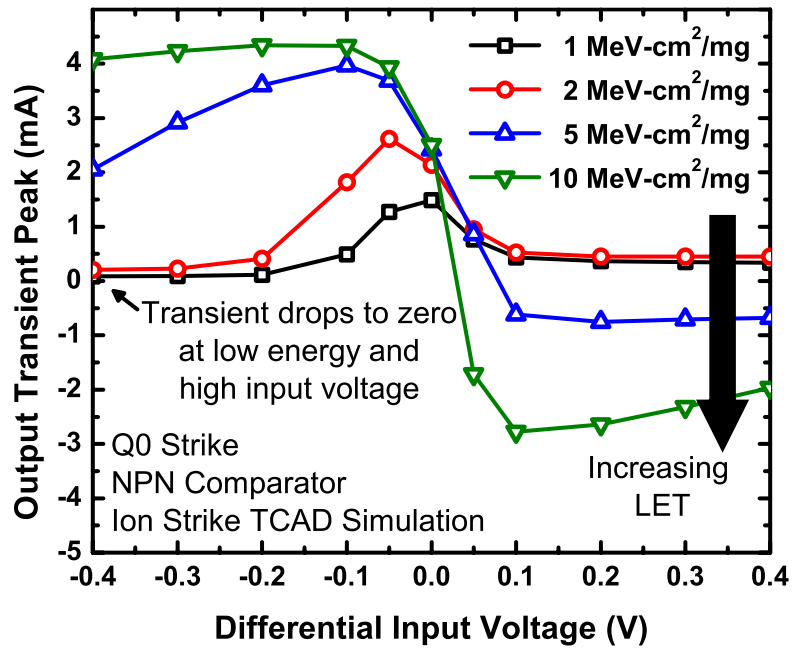
Consistent Cable Setup**



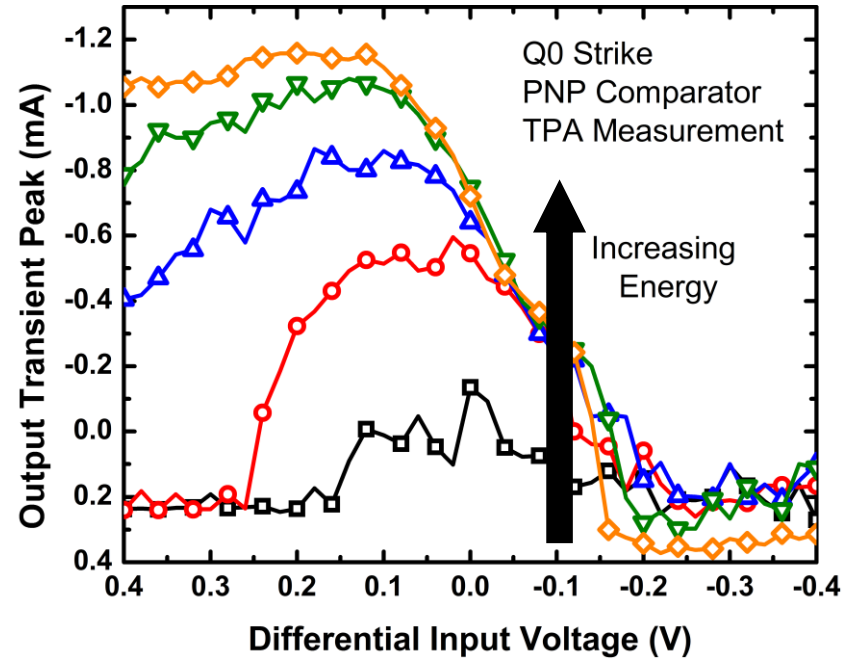
**At least at each facility

- Helps Identify Bad Data

TCAD Simulation



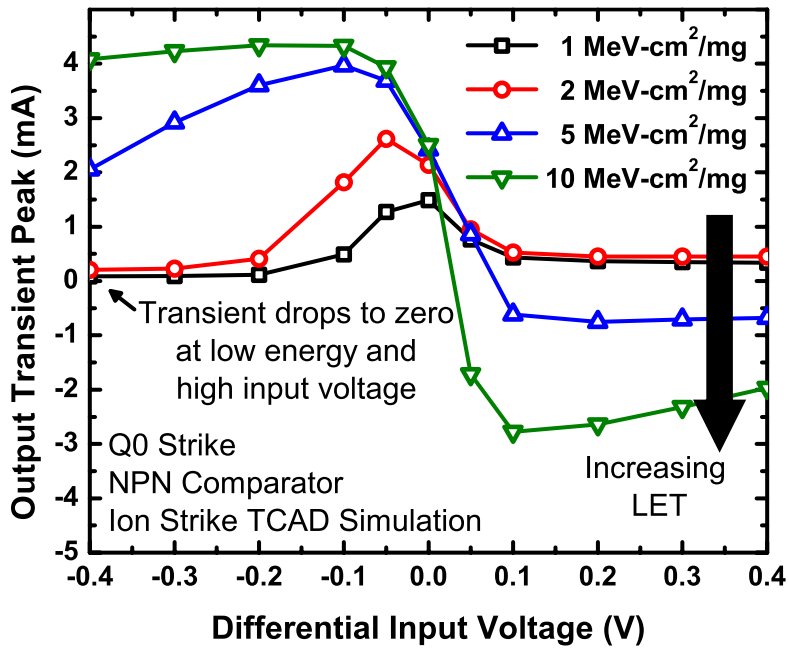
PNP Sample



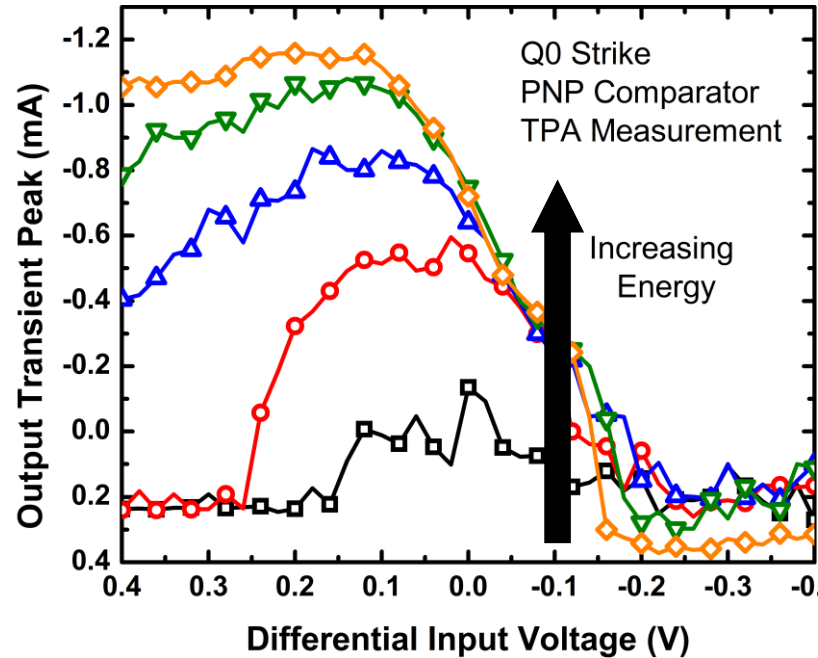
Data Validation: Plot as You Go!

- Helps Identify Bad Data

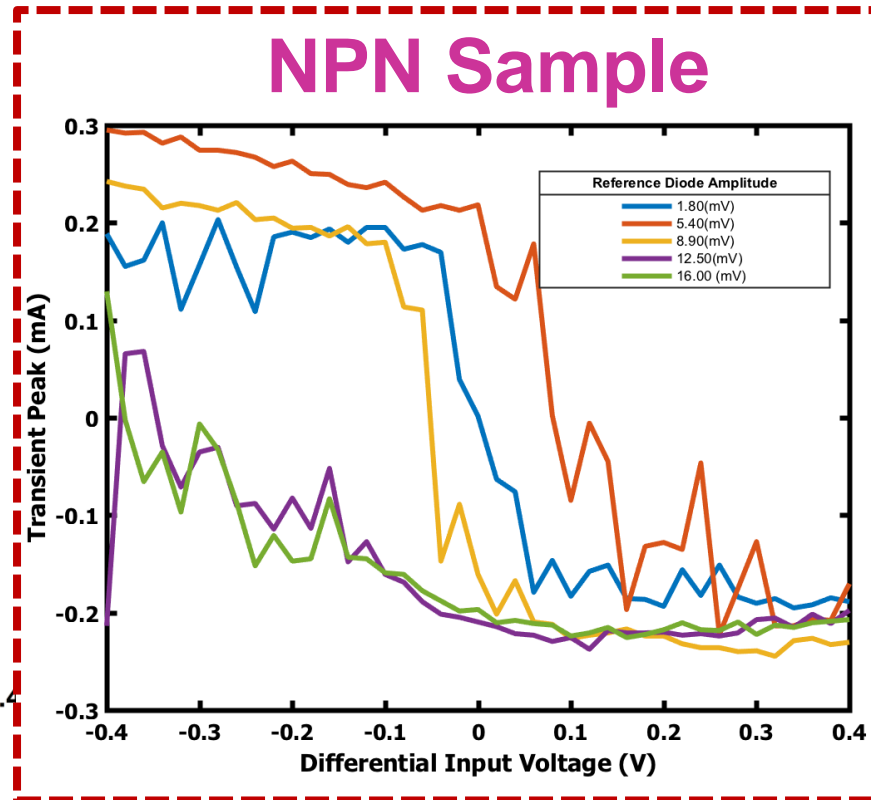
TCAD Simulation



PNP Sample

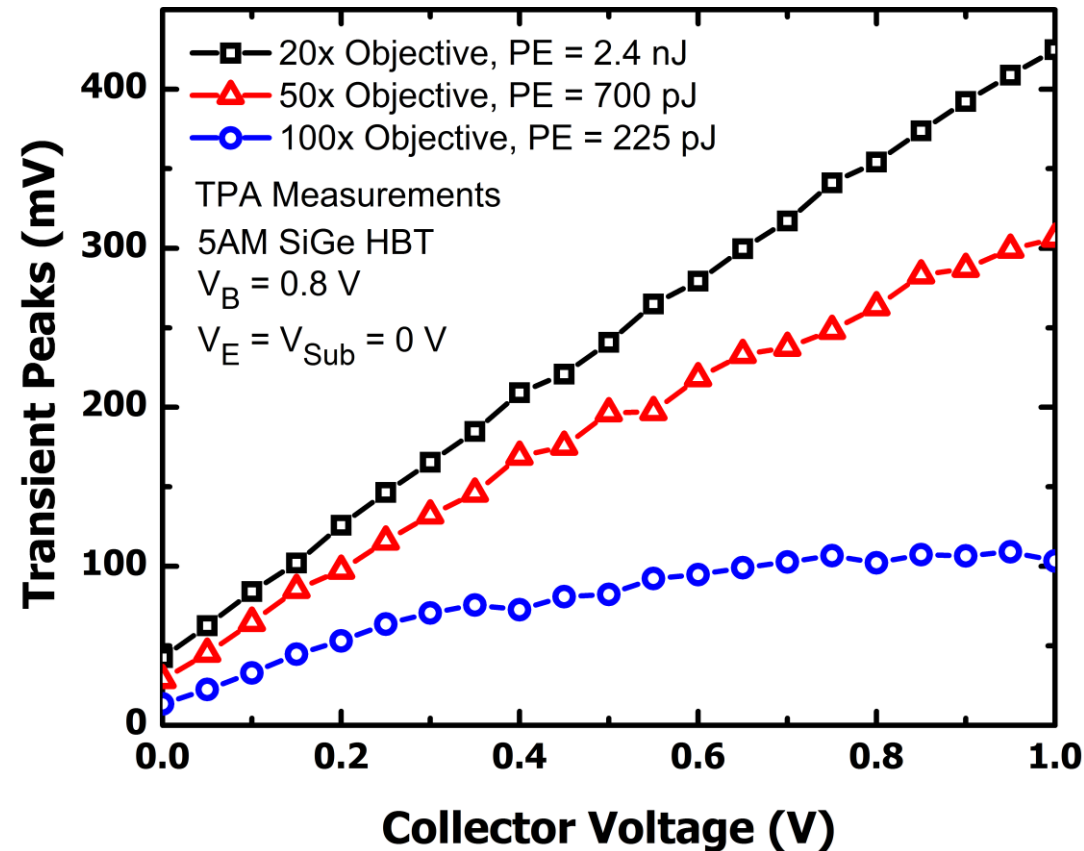


NPN Sample



Data Validation: Plot as You Go!

- Helps Identify Bad Data
- Can Show Interesting Trends not in Test Plan



- **Excellent Facility Available for Research**
 - well calibrated and able to generate reproducible results
 - beam profile and deposited charge can be predicted by simulation
 - very knowledgeable and friendly staff :)

- **Guidelines for Successful Experiments**
 - reliable laser calibration
 - consistent sample preparation
 - data validation: "plot as you go!"